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Phosphide capacities of ferromanganese smelting slags

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5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary and Conclusion

The demand for low impurity inputs by steel producers, especially low phosphorus materials motivated the need for this study. Factors which affect the slag equilibrium phosphorus distribution ratio and the slag phosphide capacity in highly reducing atmosphere were studied.

This study was carried out to determine the effect of slag composition and Po_2 on ferromanganese synthetic slag Lp and C_P^{3-} properties. Ferromanganese slag samples (MnO, SiO_2, Al_2O_3, MgO, P_2O_5 and CaO) and metal samples (Mn, Fe, Si and C) with composition typical of ferromanganese production in the Republic of South Africa were used. The slag and metal samples were equilibrated at 1500^oC in CO and Ar/CO atmospheres such that the Po_2 was 1.223×10^{-16} atm and 7.826×10^{-19} atm respectively. The final equilibrium slag and metal sample analysis results were used to develop statistical models for predicting the ferromanganese smelting slags Lp and C_P^{3-} properties at any given composition within the slag composition range considered in this research.

From the results of the final equilibrium slag and metal samples, two sets of multi variable regression models were derived using the SAS system to predict the Lp and C_P^{3-} values for ferromanganese slags under CO and Ar/CO atmospheres. The effect of slag composition and Po_2 on Lp and Cp^{3-} was determined.

The significant results obtained in this research work are summarized below:

i. The increase of SiO_2 content in the slag under both CO atmosphere and Ar/CO atmosphere resulted in a decrease of the Lp and C_P^{3-} parameters of ferromanganese slags in highly reducing atmospheres

ii. The increase of slag basicity under both CO and Ar/CO atmospheres led to an increase in both Lp and C_P^{3-} slag parameters.

iii. The increase of CaO content in the ferromanganese slags under both CO and Ar/CO atmospheres resulted in an increase of the slag Lp and C_P^{3-} parameters.

iv. Increasing the slag MgO content in CO atmosphere resulted in an increase of both Lp and C_P^{3-} slag parameters. However under Ar/CO atmosphere increasing MgO slag content was accompanied by a drop in the slag Lp and C_P^{3-} parameters due to an overall drop in slag basicity.

v. When MnO content in the ferromanganese slags was increased under both CO and Ar/CO atmospheres it was accompanied by a reduction in CaO and an increase of SiO_2 hence the overall slag basicity dropped leading to a decrease in the slag Lp and C_P^{3-} parameters.

vi. It was established that the ferromanganese slag Lp and C_P^{3-} parameters are slightly higher in CO atmospheres compared to Ar/CO atmospheres and are lowered by a reduction of the Po_2 in the controlling atmosphere.

vii. It was also established that slag composition had greater effect on Lp and C_P^{3-} slag parameters at lower Po_2 produced by Ar/CO atmosphere compared to the CO atmosphere.

From the results obtained in this research work the following conclusions can be made:

i. The slag Lp ratio is directly proportional to C_P^{3-} that is when Lp increases then C_P^{3-} also increases and vise versa in ferromanganese smelting slags.

ii. An overall resultant increase of slag basicity leads to an increase of both the Lp and C_P^{3-} slag parameters. Whilst an overall decrease of slag basicity leads to a decrease of both the Lp and C_P^{3-} slag parameters.

iii. Ferromanganese smelting slags Lp and C_P^{3-} parameters are enhanced under CO atmospheres compared to Ar/CO atmospheres with very low Po_2.

5.2 Recommendations for future work

Further equilibrium experimental work needs to be done with a fixed initial phosphorous level in the slag samples and a single alloy composition to further improve the confidence levels of the regression models by reducing the number of variables. Handling of phosphorous element powder in air was difficult as it quickly turned into a liquid phase at room temperature. It is recommended that P_2O_5 be used instead for the introduction of phosphorous into the slag phase. Use of optical basicity to determine C_p^{3-} needs to be developed in future works.